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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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DIATOMITE

BY

PAUL HATMAKER

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INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

DIATOMITE[1]

By Paul Hatmaker[2]

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DEFINITION OF DIATOMITE

Diatomite is the name now generally given to a mineral substance composed of the tiny, skeletal remains of diatoms, which are microscopic, flowerless, water plants related to the algae. This residuum is essentially hydrous amorphous silica.

Common names for diatomite are: Diatomaceous earth, tripolite, kieselguhr, and infusorial earth. Strictly speaking, however, the latter material is not diatomite, as it is composed of the fossil remains of infusoria, which usually do not occur with the diatomaceae. Other synonyms for diatomite are: Diatomaceous silica, kieselmehl, bergmehl, diatomeenpeelite, polirschiefer, moler, molera, molererde, desmid earth, fossil flour, mountain flour, farine fossil, white peat, radiolarian earth, chalk rock, ceyssatite, randanite, and tellurine; also various diatomite products of individual companies are known by their own trade names.

Diatomite should not be confused with fuller's earth, for the two are separate and distinct substances. Bentonite, pumice, and tripoli, have also been used erroneously to designate diatomite. Tripolite, however, is a true diatomite formerly mined near Tripoli.

VARIETIES

More than ten thousand varieties of diatoms have been studied and classified. Among the more important are the Coscinodiscus which resembles a golf ball in appearance and the Synedra which is long and needle-shaped. Circular disk-like forms are common. Others are of every conceivable shape and size, but all are relatively tiny. Their geometrical designs are fanciful and intricate. They may be short or long, triangular, in the form of a half-moon, needle-like, disk-shaped, spherical or ladder-shaped; in fact the variations are almost infinite. Diatoms are unicellular, and are described as being like pill boxes, with two halves that fit upon each other snugly. They range in size from that of a pin's head to minute particles visible only with a microscope of high magnification.

MODE OF LIFE

These microscopic water plants, which have such interesting posthumous value, are found in all kinds of water, quiet or moving, hot or cold, and saline or fresh. Certain conditions, however, seem to be more favorable than others for their growth and development. Light is an important factor for their propagation, while too great a salinity of water is detrimental to their well-being. For millions of years succeeding generations of diatoms have left their fossil remains in many of the rocks throughout the earth's crust.

These small organisms, some of which move freely while others attach themselves to various objects, absorb mineral salts from the water in which they live. They make skeletons of silica out of this mineral matter in much the same fashion that oysters make shells out of lime taken from sea water. Diatoms multiply rapidly, but their life span is short. After they die the organic matter decomposes, and the skeletons sink to the bottom where they gradually build up deposits of diatomite. It is estimated that there may be as many as 50,000,000 individual skeletons in a cubic inch of diatomite.

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At present diatoms are found in oceans, in swamps and lakes, and also in various hot springs. Diatoms thrive practically in every place where there is water and sufficient light.

OCCURRENCE OF DEPOSITS

In general the deposits of diatomite may be divided into three types: First, those occurring as ancient marine beds, compact and more or less massive, but sometimes with seams and partings of clay; second, deposits adjacent to rivers and lakes, probably for the most part made from fresh-water diatoms of more recent age than those in the marine beds; and third, deposits in lakes and swamps where the process of accumulation is even now going on. Deposits of the third type usually contain more or less organic matter which has not completely decomposed and which in some places is in the form of a mantle of peat-like material. Deposits as a whole vary in texture from soft mud-like or clayey masses to hard compact massive beds in the older and more consolidated formations.

The marine beds occur as sedimentary deposits, in many places conformable with the underlying strata. In some localities they are found at considerable depths, but most of the commercial deposits occur at or near the surface. Many of the deposits have a pronounced dip, which may be as much as 30° where there has been considerable subsequent tilting of the strata.

Calvert[3] states that, according to Dr. Mann, the diatoms composing the Lompoc deposits of California were of the plankton, or free moving, type, and that at some remote time the ocean was teeming with these small aquatic plants. In Miocene times they floated southward from the cold seas of the Arctic to what is now the Lompoc region. This area, according to Dr. Mann, was at that time a bottle-neck bay of the ocean. Here the minute plants died, their skeletons sank, and in the course of time built up the great beds of diatomite which are now being exploited.

These beds naturally were accumulated over long periods during which the diatoms like other transported materials were deposited according to their size and weight. In the course of their southward migration the heavy diatoms sank to the bottom while the lighter ones, which presented a maximum of surface contact and consequently a minimum tendency to settle, were carried along and finally reached a quiet, sheltered arm of the ocean. Here conditions favored mainly the deposition of fine-grained diatomite and, except for occasional streaks of clay, these beds are little contaminated by other material.

Some of the deposits in Washington and Oregon are a result of ancient volcanic dams which made lakes along the rivers. Here the accumulation of diatoms went on for a long time, occasionally interrupted by thin layers of volcanic ash from nearby active craters. Some of the deposits were covered by subsequent lava flows. Other lake beds were finally filled up either by glacial drift or water-borne material. Later when the rivers assumed their original channels, they cut down through the overlying beds and exposed the deposits of diatomite.

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3 Calvert, Robert, Diatomaceous Earth: New York, 1930, pp. 100-101.

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Many deposits in the Eastern States also are of commercial importance. In Florida, diatomite occurs in the form of a light, muddy substance, either in the bottom of lakes or hidden under the accumulated vegetable matter of swamp bottoms. Deposition in the Northeastern States probably took place in lakes and swamps. Some of the deposits are quite pure in silica content but others are contaminated with mud, clay, and glacial debris.

Many Canadian deposits occur adjacent to rivers and lakes, some as ancient marine beds, and some in swamps where the material is soft and unconsolidated.

DISTRIBUTION

Diatomite is widely distributed over the world. At present the United States has the largest commercial beds and leads in world production, with Algeria second. In the United States the most important commercial deposits are in California, although diatomite is produced in Washington, Oregon, Nevada, and some of the Eastern States. The more important occurrences of diatomite in the United States are shown in Figure 1 and are as follows:

Western States

California. - Immense deposits of marine diatomite are found along the coast of California from the southern part to a point north of San Francisco. The most important commercial deposits are in this belt, and those in Santa Barbara County, which occur in the Monterey (middle Miocene) formation, are especially important. The character of these deposits varies extremely. Some beds are soft, unconsolidated material; others are more compact and may even be flint-like. In places the diatomite grades into a shale. The color may be white, gray, yellow or black. The thickness varies from a few inches to nearly a thousand feet.

Los Angeles County.- Deposits of diatomite occur north of the San Jose Hills near Cobina, 30 miles east of Los Angeles.

San Luis Obispo County.- Deposits have been found on the south side of Los Asos, two miles south of Moro Bay and 10 miles west of San Luis Obispo.

Monterey County.- Diatomite is found near the junction of the San Antonio and Solinas Rivers, and also in the vicinity of Monterey.

Shasta County.- Deposits of diatomite occur on the Pitt River north of Burney, 50 miles east of the junction with the Sacramento River. These deposits are said to be of fresh water origin, differing in that respect from the marine deposits of the coastal region.

Oregon. - Deposits of diatomite occur in Deschutes, Baker, Grant, Klamath, Wasco, Union, Malheur and Crook Counties.

Washington. - Diatomite occurs along the Columbia River in the central portion of the State. One deposit now being worked lies about 20 miles southeast of Ellensburg.

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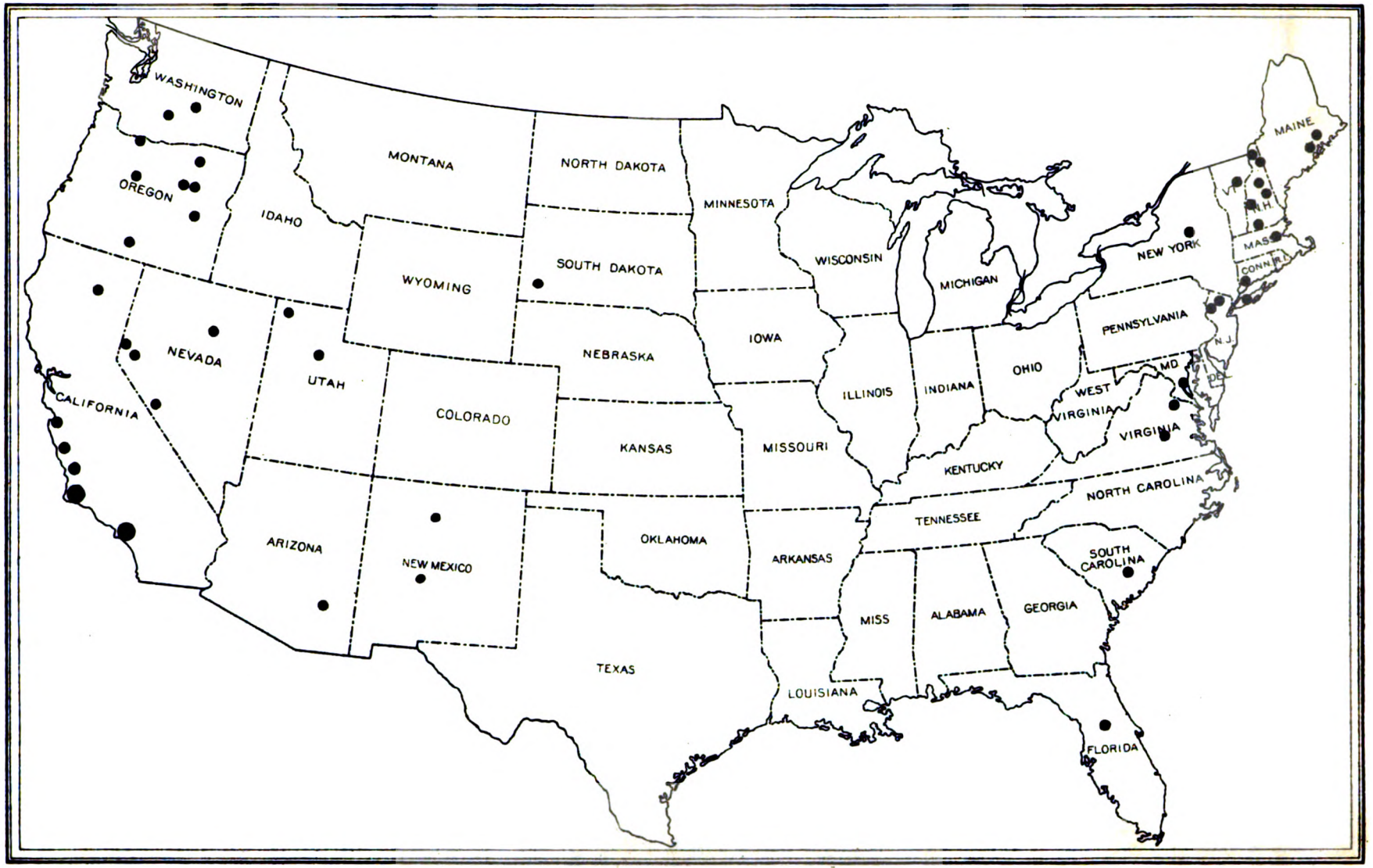

Figure 1.- Principal deposits of diatomite in the United States

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Nevada. - Diatomite has been reported from every county of the State. Those counties which have received most attention are Churchill, Elko, Esmeralda, Mineral, Nye, Pershing, Storey, and Washoe.

South Dakota. - Diatomite has been found near Hermosa in Custer County.

Arizona. - Some diatomite has been reported from the San Pedro Valley in Graham County.

New Mexico. - Deposits are reported near Espanola and Soccoro.

Utah. - Diatomite occurs in Utah County and Box Elder County.

Montana. - Diatomite has also been reported from this State.

Central States

In the Middle West diatomite deposits have been found in Missouri, Illinois, Mississippi, and other States, but their commercial importance is negligible at present.

Eastern States

Maryland. - Beds of diatomite occur in several counties from Herring Bay on the west side of Chesapeake Bay to Popes Creek on the Potomac River. There are also deposits on the Patuxent River near Dunkirk.

Florida. - Diatomite is found as fresh water deposits near Eustis and Clermont in Lake County. It occurs in the bottom of shallow lakes and in swamps.

Other States where diatomite has been found are as follows:

In Connecticut, near Stepney; in Massachusetts, near South Framingham in Middlesex County; in New Hampshire, as lake beds in the northern part of the State, at Laconia in Belknap County, in Carroll County, Cheshire County, Grafton County, and at Lake Umbagog in Coos County; in Maine, at Blue Hill and Surry in Hancock County, and South Beddington in Washington County; in Vermont, in Caledonia County; in New York, at White Lake in Herkimer County and at Cold Spring Harbor on Long Island; in New Jersey, in Morris and Sussex Counties.

In Virginia occurrences have been noted in King George County, and near Richmond in Henrico County, and northwest of Petersburg in Dinwiddie County; in South Carolina, in Williamsburg County.

Canada

The most important deposits of diatomite in Canada are found in British Columbia along the Fraser and Quesnel Rivers. It is also found at Prospect Lake near Victoria. It occurs in Tolchester, Cumberland, and Pictou Counties, Nova Scotia. Some also has been reported from the southern part of New Brunswick. In Ontario diatomite occurs in the Muskoka region, and in Montcalm and Port Leuf Counties, Quebec.

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Other Countries

In Africa diatomite deposits occur in Tripoli and in Algeria, which latter country is second to the United States in world production. Diatomite is found also in the Transvaal and the District of Masai.

In Asia the centers of production are in the Dutch East Indies along the West Coast of Sumatra, and near Cheribou in Java. Some diatomite also is found in the southern part of Japan.

In Australia, New South Wales produces an appreciable tonnage.

In Europe diatomite is found in Ireland and Scotland, in lower Austria, in the north-central part of Denmark, in Germany, Italy, Norway, Sweden, France, Portugal, Spain, Hungary, Belgium, and Russia.

Other countries of minor importance include Chile, where it is found near Arica; also Mexico, Peru, China, and Manchuria.

PROPERTIES

Physical

Color.- Diatomite is white when no impurities are present. The deposits, however, vary greatly in color, depending upon the presence of organic matter and other impurities such as clay and iron. These may change the color to gray, brown, pink or green.

Luster.- The luster of diatomite is dull and earthy. A sample of crude diatomite closely resembles chalk, but diatomite is more harsh to the touch.

True specific gravity or density.- The true specific gravity of diatomite is 2.1 to 2.2 (water is 1.0), or the same as hydrous silica such as opal.

Apparent density.- The apparent density is low because of the high porosity. Lump diatomite as it occurs in nature averages about 0.45, or weighs 28 pounds a cubic foot. However, this varies greatly, depending upon the nature of the deposit, and may be as high as 60 pounds a cubic foot. The dry, loose powder ranges from 7 to 16 pounds a cubic foot. Because of its extreme lightness and bulkiness it commands high freight rates.

Porosity.- Diatomite is a highly porous substance. A cubic foot of solid silica weighs 131.2 pounds. The difference between 131.2 and 28, the weight for a cubic foot, indicates the excessive volume of pore space in the material.

Thermoconductivity.- Because of the minute size of its air cells and its high porosity, diatomite is a very poor conductor of heat.

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Angular nature of particles.- When diatomite is finely pulverized, the minute cell walls, even though they may be broken, present sharp edges and corners of silica. On this account diatomite makes an excellent polishing medium.

Coefficient of expansion.- Unless diatomite has been subjected to very high temperatures, in which case its amorphous nature changes, it expands or contracts very little with changes of temperature. This adds to its usefulness in making insulating bricks for furnaces.

Melting point.- The melting point of silica is 1,600° C. The range for diatomite is from 1,400° C. to 1,750° C., or from 2,552° F. to 3,182° F. These variations depend upon the purity of the material and also upon its density. If it is very impure or contaminated with clay, the melting point may be as low as 1,000° C.

The index of refraction is 1.45.

Chemical

Diatomites from various parts of the United States show the following range in composition:

	Per cent
Silica (SiO_2)	65 to 97
Alumina (Al_2O_3)	0.45 to 11.71
Iron oxide (Fe_2O_3)	Trace to 3.34
Lime (CaO)	0.11 to 2.61
Magnesia (MgO)	Trace to 1.06
Potash (K_2O)	0.0 to 3.58
Soda (Na_2O)	0.0 to 1.43
Water (H_2O) and organic matter	3.40 to 14.01

Upon ignition diatomite reacts in the same manner as ordinary opal. It gives up its combined water between 500 and 800° C. It is insoluble in neutral solutions and also in acids other than hydrofluoric. It is soluble in hydrofluoric acid and in caustic alkalies such as sodium carbonate.

It may be observed from the above that diatomite is chemically inert in the presence of ordinary reagents, but its properties are affected considerably by impurities.

Diatomite does not effervesce when acids are applied to it. This quality sometimes is helpful in its recognition.

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USES

Diatomite has many important uses because of the wide adaptability of its extraordinary physical properties. It has rapidly assumed greater and greater importance in modern industry as markets are developed and industry becomes familiar with the various benefits to be derived from its use. One of the interesting features in respect to its marketing is that new uses continually are being found for diatomite which more than make up for the decrease in some of the older ones. An example of this is the employment of diatomite as an absorbent in dynamite. It is no longer used in this way, and what was once a major use now is of negligible importance. On the other hand it is comparatively recently that diatomite has been employed as a concrete admixture. Its use as a filler for battery boxes also has grown rapidly in recent years.

The more important uses are: First, as a filtration medium, second, as a heat insulation material; and third, as an admixture in concrete.

Filtration

The cane sugar industry at present is the largest consumer of diatomite. It is used mainly in filtering sugar solutions, being far superior to other media. Powdered material is added to the sugar solutions, which are then filtered through cloth. The cloth is previously prepared by coating it with a thin layer of pulverized diatomite. This is done by filtering through the cloth a small quantity of a solution carrying pulverized diatomite in suspension. This preparatory coating prevents the first filtrate from being cloudy before the added diatomite collects on the filter cloth and begins the filtering process. A high degree of efficiency is obtained by this method. For this work different varieties of diatoms are said to give different rates of filtering.

Diatomite is used to a certain extent in the beet sugar industry, but the total tonnage consumed is small in comparison with that used in the cane sugar industry.

Diatomite also may be used[4] for filtering orange juice, lemon juice, and grape juice, vinegar, pectin, citric acid, glucose, lactose, maltose, molasses, syrups, cottonseed oil, corn oil, fish oil, caster oil, lard, used crank case oil, used transformer oil, petroleum, petroleum-water emulsions, beverages, antitoxins and serums, nitro-cellulose, dyestuffs, glycerine, alcoholic extracts, adhesives, various emulsions, sewage, liquid soaps, and chemicals.

Deposits containing salt or much clay or other impurities are usually objectionable unless these impurities can be eliminated before use. Salt dissolves and contaminates the filtrate, and clay has a tendency to clog the filter cake, retarding the speed of filtration.

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4 Calvert, Robert, Page 26 of work cited.

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Heat Insulation

Owing to its extreme porosity and fineness of individual air chambers, diatomite in various forms is extensively used as insulating material. Air is a very poor conductor of heat. However, if the air chambers are large, heat is transferred by convection. If the air chambers are very small, as in diatomite, transference of heat by convection is reduced to a minimum, hence diatomite has excellent heat insulating qualities. For insulating, diatomite may be used as sawed bricks which are cut from the rock in place at the quarry, as a granular powder, as bricks which are prepared with some bonding material and then calcined, or as mortars and cements. The bricks are used extensively for lining furnaces, in which they are usually placed behind a firebrick facing and are backed up by ordinary brick. Thus sandwiched in, they are very efficient in preventing heat losses.

Eardley-Wilmot has summarized the insulating uses of diatomite, employed as powder, bricks, slabs, pipe coverings, or cements, as follows:[5]

Steam-power plant equipment:
Boilers, steam pipes, breechings and flues, superheaters, and economizers.

Petroleum refinery equipment:
Stills, still furnaces, rotary kilns, boilers, pipes, oil lines and flues, storage tanks and reservoirs, forewarmers dephlegmating towers, etc.

Iron and steel melting fabricating:
Hot-blast stoves, mains and bustle pipes, regenerators and flues, by-product coke ovens, core baking ovens, producer gas mains, billet heating furnaces, annealing furnaces, heat-treating furnaces, malleable annealing ovens, foundry ladles, furnace doors, crucible furnaces, gun furnaces.

Nonferrous smelting, refining, and fabricating:
Reverberatory furnaces, rolling-mill melting furnaces, sintering furnaces, roasters (single and multiple hearth), melting furnaces, annealing furnaces, heat-treating furnaces, calcine hoppers, zinc retorting furnaces, sulphur burners, lead pots, metal mixers.

Lime and cement plant equipment:
Rotary kilns, vertical-shaft limekilns, boilers, flues, and settling-chambers.

Glass manufacturing equipment:
Day tanks, pot arches, boilers, producer gas mains and flues, refining end of melting tanks, regenerators and recuperators, tunnel kilns for preheating pots, flattening ovens.

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5 Eardley-Wilmot, V. L., Diatomite, Its Occurrence, Preparation and Uses: Canada Department of Mines, Ottawa, No. 691, 1928, p. 14.

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Ceramic plant equipment:
Periodic kilns, tunnel kilns, fritting-furnaces, enamel drying ovens, waste heat or direct heat boilers, waste heat flues, enamelling furnaces.

Gas-generating equipment:
Water and oil gas sets, coke ovens, gas producers, mains and flues, coal gas retorts, waste heat flues, boilers (waste heat and direct fired).

General:
Bakers' ovens, crematories, driers, dust catchers, electric furnaces, evaporators, fireless cookers, forewarmers, incinerators, pipe-covering (all kinds), preheaters, safes, filing cabinets, soap-kettles, etc.

Refrigeration and construction:
Chill rooms, ice cellars, cold storages, refrigerators, in walls of buildings, roofing tiles, fireproof and other paints, and for sound deadening.

Diatomite makes good insulating material for dwellings. The usual practice is to spread 2 inches of powdered diatomite between the ceiling joists. If desired, the space between the wall studs may be filled also. This gives an insulating equivalent of 30 to 40 inches of ordinary brick and keeps the building warm in winter and cool in summer. Vermin are kept out and an added quality of fireproofing is given to the structure. Since diatomite readily absorbs moisture it should not be used near the ground level or in excessively damp places.

Pulverized diatomite bonded with about 10 per cent asbestos is made into a pipe-covering compound. The mixture is moistened with water and pressed into suitable shapes. These are usually made in longitudinal halves and wrapped with canvas upon installation.

Concrete Admixture

As a concrete admixture, from 3 to 5 pounds of pulverized diatomite may be mixed intimately with one bag of cement. The other aggregates and water are then mixed with the cement in the usual manner. It is thought that the diatomite, because of its high absorbent quality, takes up the excess water, although it probably yields some of it later during the hardening stages. Used in this way it adds greatly to the workability of the mix and retards segregation of the sand and gravel. This is a particular advantage when concrete is mixed at a central plant and where some time may elapse before it is poured into the forms. Subsequent stripping also is rendered easier. In the curing of concrete, laitance or the surface scum which usually forms is diminished by its use. Whether or not diatomite adds to the eventual strength of the concrete is a question much discussed. In many cases it probably does, not because of any inherent cementing qualities in the diatomite but because less water may be used for a given degree of workability. It is a well-known fact that too much water detracts materially from the ultimate strength of

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concrete. By using diatomite the desired workability is obtained without an excess of water and a corresponding increase in strength results. Concrete which will come in contact with the ocean is rendered more immune to the disintegrating influence of the salt water by the addition of diatomite. In this respect it has been used in the building of concrete ships. Its use also is growing for aqueducts and siphons, as concrete containing diatomite is said to be more waterproof than ordinary kinds.

It seems that the use of diatomite in concrete should eventually become of even greater importance to the diatomite industry than it is now. Further research along this line is being done.

Minor Uses

The use of diatomite as a filler for battery boxes has increased rapidly in the last few years. The annual tonnage now so employed is considerable, and this market is one of the most important of the newer outlets which are being developed. Finely ground diatomite is also used as a filler in hard-rubber products, phonograph records, papier mache, paints and varnishes, oil cloth, linoleum, insecticides, and for other purposes where a light, porous material is required.

Diatomite is used as an absorbent in the manufacture of acetylene gas. It is used also for absorbing chemicals such as bromine, alcohol, and acids, for liquid fuels, liquid manures, and disinfectants. It makes a good packing material for strong acids such as nitric and sulphuric acids because in case of breakage it tends to absorb the spilled acid.

Diatomite is used as a source of silica for ultramarine blue, and in the wet process of manufacturing water glass. Diatomite is used often as a carrier for catalysts in the hydrogenation of oils for the manufacture of soaps. Diatomite also is said to possess certain bleaching qualities.

In structural work, besides its use in concrete, diatomite is used in the manufacture of roofing tiles and for certain building blocks and bricks where light weight is desired. It may be used for soundproofing rooms and telephone booths, and fireproofing safes and storage vaults.

Because diatomite when finely pulverized yields minute particles which still retain angular characteristics, even though the individual diatoms may become broken, it is widely used as an abrasive for polishing. Where metal surfaces are required to take a high luster, the desired effect or polish is had by making minute microscopic scratches on the metal which in turn reflect light. Pulverized diatomite sometimes mixed with other ingredients makes an ideal material for this purpose.

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Many metal polishes now on the market use diatomite as a base. The small, tough, freshwater varieties are said to be the best for this purpose. Polishes of this kind may be used for silverware and for scientific and surgical instruments. Such polishes usually are marketed in the form of pastes or powders. Diatomite also may be used in automobile polishes, and the purest and finest material is used to some extent in dental powders and pastes and in finger-nail polishes.

Diatomite has been used as a parting medium in steel foundry practice, as a substitute for chalk in crayons, and as dusting powders for automobile tubes and tracing cloth. Diatomite is used to some extent in the ceramic industry in the manufacture of porcelains and tiles, as an adulterant in cheap foodstuffs, as a constituent of modelling putty and shoe polishes, and as a medium through which to blow air for aerating liquids.

MINING

Commercial deposits of diatomite may be divided into three general types: First, those close to the surface, which may be mined by quarry methods; second, those which extend deeper and are exploited by shaft and stoping; and third, those which occur in shallow lakes or swamps.

The California deposits are of the first two types. For quarrying operations the overburden is removed either by machinery or by scrapers and hand tools. Blasting usually can not be resorted to in this operation as it might shatter the underlying beds. After the strata of diatomite are cleaned off, the actual quarrying is begun and benches are developed as fast as possible in order to give a sufficient number of working places. Any clay partings in the beds aid in the splitting off of slab material, although sometimes light charges of powder are employed. For certain types of products the material is sawn nearly to the desired shape by means of specially constructed machinery in the quarry. Otherwise the slabs are pried out by hand or loosened by small charges of powder and then shoveled into wagons for transference to drying sites. Power shovels are not used to any appreciable extent, although in Washington there is a deposit near Ellensburg where a gasoline shovel is used to strip off the overburden and also to load trucks with diatomite.

Recent practice at the larger operations is to mine the great beds of diatomite by underground methods. From a main haulage tunnel raises are put up at suitable intervals to the strata desired, and stoping is done by room-and-pillar methods. The loosened and broken diatomite is handled by scrapers to the raises from which it is passed down to cars in the haulage tunnel. Such mining methods may be supplemented by quarry operations in the general mining scheme.

In Nevada a deposit of diatomite is mined from a shaft which is sunk parallel to the dip of the strata. From the shaft drifts are run at suitable intervals along the strike, after which stoping proceeds. Pillars left for support are to be removed later.

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In Lake County, Fla., the diatomite is found in shallow water deposits. A floating dredge is used with a suction hung from a boom. It is equipped with specially constructed revolving blades which collect the loose material, after which it is conveyed to the top.

In some cases it is feasible to drain a shallow lake before attempting to recover the beds of diatomite. Usually, however, this practice is much too expensive, and some form of dredging must be resorted to.

PREPARATION FOR MARKETING

Crude diatomite because of its sponge-like qualities naturally tends to soak up ground water or rain. Therefore, after being mined, the first step in the preparation of the material is to eliminate this uncombined water - uncombined because it is in addition to the 4 or 5 per cent of water which is locked up chemically with the silica and can be driven off only by calcination. Removal of this excess sponge-water may be done in several ways. At some plants the material, in the form of slabs, is carted to suitable drying sites. There it is stacked in long windrows where the hot, dry desert winds remove most of the uncombined water. After being allowed to dry in this manner for several weeks the moisture content is reduced to 10 per cent or less and the material may be carted to the grinding plant.

In regions which do not have these natural drying conditions the material must be dried by artificial means. Also, recent practice at the larger plants is to do most of the drying in ovens or kilns even though natural drying conditions are available.

Where a pulverized product is desired, common practice is as follows:

After the preliminary drying, done either by natural or artificial means, the material is passed through crushers or toothed rolls. A trommel returns the oversize and passes the undersize to some form of pulverizer, such as the swinging-arm type. Pulverizing must be done carefully. The object is to free the individual diatoms but not to crush them unnecessarily. The material from the pulverizer is screened and the coarser sizes are ready for packing. The finer material is passed through a series of cyclone air separators which classify it to the various fine sizes desired. Prior to air classifying, sand traps remove as many of the objectionable impurities as possible. The material from the cyclones is sacked and is then ready for shipment. Sometimes these sacks are passed between light rolls to compress them so that more may be loaded into the freight car.

Two classes of diatomite brick are made, sawed brick and pressed brick. The sawed brick may be of two kinds, natural or calcined. In preparing natural brick, diatomite is cut in the quarry nearly to size by specially constructed saws. The brick are then dried and are trimmed by grinders, after which they are packed in cartons. The calcined brick are fired to the desired temperature, after which they are packed for shipment.

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There are three general varieties of pressed brick. First, the ordinary brick which is made from a high-quality diatomite. The powdered or granulated diatomite is moistened with water to a paste, pressed to shape, dried and fired to the desired temperature. Sometimes bonding materials are used, such as lime or clay.

The second class of pressed brick is made from a heavier form of diatomite. This is lightened by the inclusion of organic matter, such as cork, which burns away during the firing process. This leaves many small cavities throughout the brick, which add to the lightness and porosity.

The third type of pressed brick is largely in the form of tridymite. Where a brick is desired to withstand high temperatures this type is recommended by the manufacturers. At certain high temperatures the crystalline form of silica changes to either cristobalite or tridymite. Cristobalite is very objectionable because it contracts or expands appreciably with only slight changes in temperature. This, of course, would result in spalling or cracking. Tridymite, however, maintains a nearly even size.

Coss, U. S. Patent 1,544,433, has patented a process for making tridymite brick for high temperature insulation, such as for marine boilers. A binder of a refractory clay is used with 1 to 3 per cent of lime which, it is claimed, favors the transformation of amorphous silica to tridymite when fired at a temperature of 2,500° F.

In Florida the material after being dredged is allowed to settle in long boxes or vats. The water is drained off and the material, which is by now more or less consolidated, is air-dried, passed to vacuum chambers for further drying, and then to furnaces which burn out all organic matter. It is next crushed or pulverized, sized, and packed for shipment.

In a Nevada mill the very wet material is given a preliminary crushing and is then dried on conveyors by steam in a closed room. It is next pulverized, screened, and passed to the cyclone system for final classification.

MARKETING, PRICES, AND BUYERS

Any one contemplating the marketing of diatomite should bear in mind that its uses are somewhat dependent upon the kinds of diatoms and their individual characteristics. For instance, qualities of heat insulation may vary between wide limits, depending upon the physical properties of the different varieties of diatoms and impurities present. As most United States diatomite is mined by one producer and marketed under trade names, no general specifications can be laid down concerning the various products.

Before any attempt is made to place new material upon the market a very thorough investigation should be conducted. This should include complete chemical and physical analyses of samples taken from the separate horizons of the deposit.

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Check runs should also be made from different places in the same horizon. Chemical analyses will give data on the various impurities such as organic matter, salt, clay, etc. Physical tests should include a microscopic examination to learn something of the kinds of diatoms present. The moisture content, porosity, and specific gravity also should be determined.

It would be advisable to make actual tests of the material in the uses contemplated. For example, if it were thought that a particular deposit was suitable for use in filtering, experiments should be made with the solutions it was intended to filter. This applies equally with proposed uses as insulating material because of the wide variation in the heat insulating qualities of the various types of diatoms. In fact, all considered uses should always have exhaustive preliminary tests.

Owing to their fragile nature, for shipment bricks or blocks are placed in crates or cartons. Crude, air-dried material is customarily packed in burlap sacks of 90 to 100 pounds each. Pulverized diatomite may be packed in paper bags. Bulk shipments also are made.

Transportation is an important marketing problem. Owing to its relatively light weight and corresponding bulk, diatomite commands high freight rates, and a minimum carload of 20 tons is seldom attained. For this same reason the cost of containers per ton is relatively high. The fact, too, that most of the larger deposits occur in the West tends to make the material rather costly for eastern consumers.

The latest available prices as quoted in "Metal and Mineral Markets," Engineering and Mining Journal, June 5, 1930, are as follows:

> Diatomite per short ton, f.o.b. producing plant:
> Kiln-fired brick, $65; kiln-fired aggregate, ¼", $45;
> insulating powder $25; natural aggregate ¼" $18 @ $20;
> air floated powder, $45; 80 to 85% silica, 98 per cent
> through 200 mesh, $20 in carload lots.

These quotations are more or less nominal and should be taken only as a rough guide because diatomite at present is sold largely under contract between the individual producers and the consumers. Prices of these contracts may vary greatly from the above figures because of the various factors involved such as tonnage, individual specifications, and characteristics of the material. They are usually the result of direct negotiation between the producer and the buyer.

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Buyers.- The following companies are some of the more important buyers of diatomite.

Jerome Alexander, 50 east 41st Street, New York, N. Y.
F. Behrend (Inc.), 170 Front Street, New York, N. Y.
Bon Ami Co., 17 Battery Place, New York, N. Y.
H. C. Bugbird Co., 59 Pearl Street, New York, N. Y.
Charles B. Chrystal Co. (Inc.), 99 John Street, New York, N. Y.
Cooper & Cooper (Inc.), 23 Cliff Street, New York, N. Y.
Eimer & Amend, 201-209 east 13th Street, New York, N. Y.
The Exolon Co., Commercial Avenue & Erie R. R., Blasdell, N. Y.
Hammil & Gillespie (Inc.), 240 Front Street, New York, N. Y.
The Harshaw Chemical Co. of New York, (Successors to The Superfos Co. (Inc.)), 150 Nassau Street, New York, N. Y.
Leon Hirsh & Son, 368 Greenwich Street, New York, N. Y.
J. L. Hopkins & Co., 135 William Street, New York, N. Y.
Industrial Chemical Sales Co., 230 Park Avenue, New York, N. Y.
Innis, Speiden & Co. (Inc.), 50 Cliff Street, New York, N. Y.
A. Klipstein & Co., New York, N. Y.
Larkin Co. (Inc), 680 Seneca Street, Buffalo, N. Y.
New England Quartz Co. of New York, 152 Nassau Street, New York, N. Y.
Orelite Co. (Inc.), 109 Broad Street, New York, N. Y.
Pomeroy & Fischer (Inc.), 95 Madison Avenue, New York, N. Y.
L. A. Salomon & Bro., 216 Pearl Street, New York, N. Y.
Wm. H. Scheel (Department A), 179 Water Street, corner Burling Slip, New York, N. Y.
Smith Chemical & Color Co. (Inc.), Moore & South Streets, New York, N. Y.
Samuel H. French & Co., 400-412 Callowhill Street, Philadelphia, Pa.
General Refractories Co., 106 south 16th Street, Philadelphia, Pa.
Shimer & Co. (Inc.), 133 south Fourth Street, Philadelphia, Pa.
Charles W. Young & Co., 1247 north 26th Street, Philadelphia, Pa.
R. F. McGrory Co., Calhoun Street & Pashley Avenue, Trenton, N. J.
Thomas Manufacturing Co., 117 west Camden Street, Baltimore, Md.
Mineral Soap Manufacturing Co., Lowell, Mass.
Abbott Laboratories, 14th Street & Sheridan Road, North Chicago, Ill.
Holman Soap Co., 3104 Fox Street, Chicago, Ill.
Hylonite Products Co., 1107 Addison Street, Chicago, Ill.
Tamms Silica Co., 30 north La Salle Street, Chicago, Ill.
Wishnick-Tumpeer (Inc.), 363 east Illinois Street, Chicago, Ill., 251 Front Street, New York, N. Y., Davenport & east 14th Streets, Cleveland, Ohio.
Coleman & Bell Co. (Inc.), Norwood, Ohio.
The DuBois Soap Co., 1120 west Front Street, Cincinnati, Ohio.
Excelsior Ball Clay Co., 31 East 13th Street, Cincinnati, Ohio.
The Globe Chemical Co., Murray Road & Big Four R. R., St. Bernard, Cincinnati, Ohio.
National Sales (Corp.), 31-35 east 13th Street, Cincinnati, Ohio.
Rub-Tex Products (Inc.), Indianapolis, Ind.
Braun (Corp.), 363 New High Street, Los Angeles, Calif.
Los Angeles Soap Co., 617 east First Street, Los Angeles, Calif.
Algernon Lewin Curtis, P.O. Box 61, Westmoore Laboratory, Chatteris, England.

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PRODUCERS

Companies in the United States reporting to the Bureau of Mines as producers of diatomite in 1929 are as follows:

California
- Fresno County: Mendota - Mineral Products Manufacturing Co. (1735 Ventura Avenue, Fresno).
- Los Angeles County: Torrance - Floatstone Products Co. (423 Wall Street, Los Angeles).
- Monterey County: Monterey (near) - The Calatom Co. (Inc.), (Monterey); Pacatome Co. (814 Kohl Building, San Francisco).
- Santa Barbara County: Lompoc - (Celite Corporation) Johns-Manville Corp. (292 Madison Avenue, New York, N. Y.).

Oregon
- Deschutes County: Terrebonne - Atomite Corporation (1021 Pacific Building, Portland).
- Malheur County: Harper - Whiteurth Products Corporation. (Harper, Oregon).

Washington
- Kittitas County: Kittitas - Kittitas Diatomite Co. (Ellensburg).
- Roza - Washington Silica & Fire Clay Co. (3205 Hewitt Avenue, Everett).

Nevada
- Elco County: Carlin - Carlin Products Co. (Inc.), (676 Subway Terminal Building, Los Angeles, Calif.); Tri-o-lite Products Co. (Carlin, Nevada).
- Esmeralda County: Basalt (near) - U. S. Diatom Co. (800 Santa Fe Avenue, Los Angeles, Calif.).
- Storey County: Virginia City - The Electro-Silicon Co. (22 Cliff Street, New York, N. Y.).

Florida
- Lake County: Clermont - Florida Diatomite Co.

Virginia
- Westmoreland County: Oak Grove - American Diatom Co. of Virginia (618 Witherspoon Building, Philadelphia, Pa.).

Maryland
- Calvert County: Dunkirk (near) - Diatomaceous Products Co. (Inc.), (907 Fifteenth Street, N. W., Washington, D. C.

New York
- Herkimer County: Poland - Adirondack Diatomaceous Earth Co. (Herkimer).

New Hampshire
- Grafton County: Canaan - New England Minerals (Inc.), (85 Devonshire Street, Boston, Mass.).

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PRODUCTION STATISTICS

World production of diatomite by countries, 1920-1928, in metric tons

Country	1920	1921	1922	1923	1924	1925	1926	1927	1928
Algeria	1,500	800	2,480	10,000	a9,092	a8,343	a7,931	a9,542	a10,144
Australia:									
New South Wales.	390	209	489	523	573	712	926	1,229	1,381
Canada	(b)	(b)	199	118	30	(c)	(c)	241	334
France	3,800	4,580	4,620	4,550	2,300	1,500	7,130	(d)	(d)
Germany (exports).	4,943	e3,415	5,207	4,096	4,326	4,555	5,919	6,023	6,703
Ireland (northern)	6,203	4,228	1,909	1,680	2,480	3,397	3,023	3,427	4,312
Italy	25	875	175	420	420	420	1,200	700	1,180
Japan.....	(b)	(b)	4,690	5,319	5,040	4,727	(d)	(d)	(d)
Norway (exports)..	75	113	82	110	67	48	58	80	84
Russia	(b)	(b)	(b)	(d)	(d)	2,344	8,055	5,187	(d)
Sweden	(d)	600	322	696	608	819	475	622	(b)
Union of South Africa	(b)	(b)	(b)	217	236	(c)	(d)	(c)	(c)
United States	56,174	50,016	40,606	59,722	57,300	66,251	79,039	(f)	(f)

a Exports.
b No record.
c No production.
d Data not available.
e Figures from May to December, 1921.
f Bureau of Mines not at liberty to publish figures.

ECONOMIC CONDITION OF THE INDUSTRY

The size of the industry at present is due quite largely to the educational advertising and pioneer work of one company which is now the largest single producer. Because of this dominant position of an individual concern the recent production figures may not be published. However, the volume produced has enjoyed a vigorous increase for some time.

Further development and enlargement of markets is still possible. Owing to its peculiar characteristics diatomite has a very wide range of uses. As an admixture to concrete there would seem to be a tremendous potential field of consumption which should open up as further research work is done and more complete specifications for its use laid down. Much wider use is possible for insulation in steam plants and in buildings, in the separation of water-oil emulsions, and for reclaiming lubricating oil.

With the growth of consumption new deposits will naturally be looked to with interest. Some of these, no doubt, may be opened and operated profitable. Taken as a whole, the diatomite industry is a specialized ore, requiring continuous comprehensive research work on the crude material, and its preparation and sale. Scientific and engineering skill is demanded throughout if the requirements of the consumer are to be met satisfactorily and profitably. Failures have resulted in the past from a lack of these essentials.

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